AMENDMENT TO THE CLAIMS

In The Claims

Claims 1-88 remain in this application. Claims 1, 2, 14, 33, 45, 70 and 84 have been amended. No claims have been added or canceled.

A listing of claims follows:

1. (Currently Amended) An apparatus comprising:

a wavelength division multiplexing optical network including optical network devices, interconnected by links, that propagate along said links connectivity request messages, initiated at each of said optical network devices acting as an access node, to discover possible end to end paths that meet a set of zero or more connectivity constraints, wherein an end to end path is a series of two or more of said optical network devices connected by links on which a set of wavelengths is available for establishing a lightpath; and

said optical network devices acting as access nodes each including a database representing available paths grouped by common destination nodes with costs from that access node to reachable destination nodes, each of said paths having associated with it in said database the wavelengths available on that path.

2. (Currently Amended) The apparatus of claim 1, wherein each of said databases stores said available paths ~~grouped by common destination nodes and~~ sorted in each group at least in part by the cost.

3. (Previously Presented) The apparatus of claim 1, wherein said available paths include lightpaths.

4. (Previously Presented) The apparatus of claim 1, wherein said available paths include one or more of optical circuits, lightpaths, and end-to-end unidirectional paths.

5. (Previously Presented) The apparatus of claim 1, wherein each of said available paths in each of said databases is a sequence of optical network devices and interconnecting links.

6. (Previously Presented) The apparatus of claim 5, wherein the wavelengths available on each of said available paths are those wavelengths common to all of the interconnecting links of that path.

7. (Previously Presented) The apparatus of claim 1, wherein said optical network devices acting as access nodes each also includes:

a regular path module to select from said available paths a path and an unallocated wavelength thereon.

8. (Previously Presented) The apparatus so claim 1, wherein said optical network devices acting access nodes each also includes:

a disjoint path module to, based on an input path and said database, select from ones of said available paths a disjoint path and an unallocated wavelength thereon.

9. (Previously Presented) The apparatus of claim 8, wherein each of said disjoint path modules is at least to determine at least one of fully node disjoint type paths and maximally node disjoint type paths.

10. (Previously Presented) The apparatus of claim 8, said each of disjoint path modules is at least to determine at least one of fully link disjoint type paths and maximally link disjoint type paths.

11. (Previously Presented) The apparatus of claim 1, wherein said optical network devices acting as access nodes each also includes:

a demand module to respond to requests for paths received by said access node;

a path selection module to, based at least in part on input destination nodes, select from the available paths in said database associated with the input destination nodes and select unallocated wavelengths thereon; and

an allocate module to cause allocation said selected paths and wavelengths in real time.

12. (Previously Presented) The apparatus of claim 1, wherein each of said optical network devices acting as an access node builds and maintains said database.

13. (Previously Presented) The apparatus of claim 1, wherein each of said optical network devices, responsive to each received connectivity request message, to determine any adjacent optical network devices to which the possible end to end path that the connectivity request message has already collected can be extended to form additional possible end to end paths having the originating access node as the source node and meeting the set of connectivity constraints, to transmit a message carrying that determination back to the originating access node of the connectivity request message

responsive to which that message was generated for storage in the database of that node, and to propagate said connectivity request message to any adjacent optical network devices that may be able to determine additional possible end to end paths having the originating access node as the source node and meeting the set of connectivity constraints.

14. (Currently Amended) An apparatus comprising:

an access node, to be coupled in a wavelength division multiplexing optical network, including,

a database to store a representation of available paths grouped by common destination nodes with costs from the access node to reachable destinations organized by said reachable destinations; and

a path selection module to select from said database ones of said available paths and unallocated wavelengths thereon.

15. (Previously Presented) The apparatus of claim 14, wherein said database includes a destinations structure to store each of said destinations in a single entry, each of said entries being associated with the sequence of nodes and links of those of the available paths that reach that entries destination, each of said series having associated with it the set of wavelengths available on the one of the available paths represented by that series.

16. (Previously Presented) The apparatus of claim 14, wherein said available paths include lightpaths.

17. (Previously Presented) The apparatus of claim 14, wherein said available paths include one or more of optical circuits, lightpaths, and end-to-end unidirectional paths.

18. (Previously Presented) The apparatus of claim 14, wherein each of said available paths is represented in said database by the series of two or more nodes and the interconnecting links over which that path travels.

19. (Previously Presented) The apparatus of claim 18, wherein each of said available paths is also represented in said database by a path channel set that includes one or more wavelengths common to all of the interconnecting links of that communication path.

20. (Previously Presented) The apparatus of claim 14, wherein said path selection module comprises:

a regular path module to select from said available paths a selected path and an unallocated wavelength thereon.

21. (Previously Presented) The apparatus of claim 14, wherein said path selection module comprises:

a disjoint path module to, based on an input path having a given one of said destinations, select from ones of said available paths a disjoint path and unallocated wavelength thereon.

22. (Previously Presented) The apparatus of claim 21, wherein said disjoint path module is at least to determine the intersection of the intermediate nodes of said input path and the intermediate nodes of a candidate path in said database that has the same source and destination nodes as said input path.

23. (Previously Presented) The apparatus of claim 21, said disjoint path module is at least to determine the intersection of the interconnecting links of said input path and the

interconnecting links of a candidate path in said database that has the same source and destination nodes as said input path.

24. (Previously Presented) The apparatus of claim 14, wherein said access node further comprises:

an allocate module, coupled to said path selection module, to cause allocation of paths and wavelengths thereon in real time.

25. (Previously Presented) The apparatus of claim 24, wherein said access node further comprises:

a demand module, coupled to said path selection module and said allocate module, to respond to requests for paths received by said access node.

26. (Previously Presented) The apparatus of claim 14, wherein said access node includes additional modules to build and maintain said database in said access node.

27. (Previously Presented) The apparatus of claim 26, wherein said access node employs a distributed search based scheme to build and maintain said database.

28. (Previously Presented) The apparatus of claim 14, wherein said access node further comprises:

a start up module to generate and transmit to adjacent nodes connectivity request messages to determine possible paths having said access node as a source node and meeting a set of zero or more connectivity constraints; and

a connectivity request module, responsive to each received connectivity request messages, to determine any adjacent nodes to which the possible path that

the connectivity request message has already collected can be extended to form additional possible paths having the originating access node as the source node and meeting the set of connectivity constraints, to transmit a message carrying that determination, and to propagate said connectivity request message to any adjacent nodes that may be able to determine additional possible paths having the originating access node as the source node and meeting the set of connectivity constraints.

29. (Previously Presented) The apparatus of claim 28, wherein each of the messages carrying a determination is transmitted back to the originating access node of the connectivity request message responsive to which that message was generated, and wherein said start up module is also to build said database responsive to receiving the messages carrying determinations of additional possible paths having the access node as the source node and meeting the set of connectivity constraints

30. (Previously Presented) The apparatus of claim 14, wherein said access node further comprises:

a module to build said database based upon data collected by OSPF.

31. (Previously Presented) The apparatus of claim 14, further comprising:

a centralized network management server communicatively coupled to said access node to build and maintain the database.

32. (Previously Presented) The apparatus of claim 14, wherein said access node further comprises:

a link state database to store, for each link connected to said access node, a link state structure to store a port of the access node to which that link is connected and available wavelengths on that link; and

a link protocol module to populate said link state database.

33. (Currently Amended) An apparatus comprising:

an access node, to be coupled in a wavelength division multiplexing optical network, including,

a set of modules to propagate through said optical network connectivity request messages, initiated at each of the access nodes in said optical network, to discover possible end to end paths that meet a set of zero or more connectivity constraints, wherein an end to end path is a series of two or more nodes connected by links on which a set of wavelengths is available for establishing a lightpath; and

a database, to be built responsive to receiving response messages carrying determinations of possible paths having the access node as the source node and meeting the set of connectivity constraints, to store available end to end paths grouped by common destination nodes with costs from the access node to reachable destination nodes organized by said reachable destination nodes.

34. (Previously Presented) The apparatus of claim 33, wherein said database includes a destinations structure to store each of said destinations in a single entry, each of said entries being associated with the sequence of nodes and links of those of the available paths that reach that entries destination, each of said series having associated with it the set of wavelengths available on the one of the available paths represented by that series.

35. (Previously Presented) The apparatus of claim 33, wherein said available paths include lightpaths.

36. (Previously Presented) The apparatus of claim 33, wherein said available paths include one or more of optical circuits, lightpaths, and end-to-end unidirectional paths.

37. (Previously Presented) The apparatus of claim 33, wherein each of said paths is represented in said database by the series of two or more nodes and the interconnecting links over which that path travels.

38. (Previously Presented) The apparatus of claim 37, wherein each of said available paths is also represented in said database by a path channel set that includes one or more wavelengths common to all of the interconnecting links of that path.

39. (Previously Presented) The apparatus of claim 33, wherein access node further comprises:

a regular path module to select from said paths in said database a selected path and an unallocated wavelength thereon.

40. (Previously Presented) The apparatus of claim 33, wherein access node further comprises:

a disjoint path module to, based on an input path having a given one of said destinations, select from ones of said paths in said database a disjoint path and unallocated wavelength thereon.

41. (Previously Presented) The apparatus of claim 40, wherein said disjoint path module is at least to determine the intersection of the intermediate nodes of said input

path and the intermediate nodes of a candidate path in said database that has the same source and destination nodes as said input path.

42. (Previously Presented) The apparatus of claim 40, said disjoint path module is at least to determine the intersection of the interconnecting links of said input path and the interconnecting links of a candidate path in said database that has the same source and destination nodes as said input path.

43. (Previously Presented) The apparatus of claim 33, wherein said access node further comprises:

an allocate module to cause allocation of paths and wavelengths thereon in real time.

44. (Previously Presented) The apparatus of claim 33, wherein said access node further comprises:

a link state database to store, for each link connected to said access node, a link state structure to store a port of the access node to which that link is connected and available wavelengths on that link; and

a link protocol module to populate said link state database.

45. (Currently Amended) An apparatus comprising:

an access node, to be coupled in a wavelength division multiplexing optical network, including,

a database organized by the destination nodes of the available paths from the access node to others of said access nodes and grouped by common destination node, each such destination node having associated to it those of the available paths that lead to that

destination node, each such available path having associated to it a path channel set that includes one or more wavelengths common to all of the interconnecting links of that path, and

a disjoint path module to select, based at least in part on an input path, a disjoint path from the available paths associated in said database with the same destination nodes as said input path and select an unallocated wavelengths thereon.

46. (Previously Presented) The apparatus of claim 45, wherein said disjoint path module is at least to select one or more of fully node disjoint type paths and maximally node disjoint type paths.

47. (Previously Presented) The apparatus of claim 45, wherein said disjoint path module is at least to select one or more of fully link disjoint type paths and maximally link disjoint type paths.

48. (Previously Presented) The apparatus of claim 45, wherein said disjoint path module is at least to determine the intersection of the intermediate nodes of said input path and the intermediate nodes of a candidate path in said database that has the same source and destination nodes as said input path.

49. (Previously Presented) The apparatus of claim 45, said disjoint path module is at least to determine the intersection of the interconnecting links of said input path and the interconnecting links of a candidate path in said database that has the same source and destination nodes as said input path.

50. (Previously Presented) The apparatus of claim 45, wherein said available paths include lightpaths.

51. (Previously Presented) The apparatus of claim 45, wherein said available paths include one or more of optical circuits, lightpaths, and end-to-end unidirectional paths.

52. (Previously Presented) The apparatus of claim 45, wherein each of said available paths in each of said databases is represented by the series of two or more nodes and the interconnecting links over which the paths travels.

53. (Previously Presented) The apparatus of claim 45, wherein the access node further comprises:

a regular path module to select a path from said available paths in said database associated with an input destination node and select an unallocated wavelengths thereon.

54. (Previously Presented) The apparatus of claim 45, wherein said access node also includes an allocate module, coupled to said disjoint path module, to allocate in real time lightpaths having that access node as a source node.

55. (Previously Presented) The apparatus of claim 45, wherein said access node including modules to participate in a distributed search based scheme to build and maintain said database.

56. (Previously Presented) The apparatus of claim 45, wherein said access node further comprises:

a start up module to generate and transmit to adjacent nodes connectivity request messages to determine possible paths having said access node as a source node and meeting a set of zero or more connectivity constraints; and

a connectivity request module, responsive to each received connectivity request messages, to determine any adjacent nodes to which the possible path that the connectivity request message has already collected can be extended to form additional possible paths having the originating access node as the source node and meeting the set of connectivity constraints, to transmit a message carrying that determination, and to propagate said connectivity request message to any adjacent nodes that may be able to determine additional possible paths having the originating access node as the source node and meeting the set of connectivity constraints.

57. (Previously Presented) The apparatus of claim 56, wherein each of the messages carrying a determination is transmitted back to the originating access node of the connectivity request message responsive to which that message was generated, and wherein each of said start up modules is also to build said database in its access node responsive to receiving the messages carrying determinations of additional possible paths having the access node as the source node and meeting the set of connectivity constraints.

58. (Previously Presented) The apparatus of claim 45, wherein said access node further comprises:

a module to build and maintain said database based upon data collected by OSPF.

59. (Previously Presented) The apparatus of claim 45, wherein said access node further comprises:

for each link connected to the access node, a link channel set representing at least certain wavelengths on that link available for establishing a lightpath, wherein a lightpath is a wavelength and a path, wherein the path of a given lightpath is a series of two or more nodes and links interconnecting them through which traffic is carried by the wavelength of that lightpath, wherein said series of nodes respectively starts and ends with a source node and a destination node, wherein the available paths in said database are the lightpaths from the access node to others of said access nodes using the wavelengths in said link channel sets.

60. (Previously Presented) An apparatus comprising:

an access node, to be coupled in a wavelength division multiplexing optical network, including,

a database to store available paths with costs from that access node to reachable destination nodes in said database, wherein each of said available paths is a series of nodes and interconnecting links in said optical network over which that path travel, said database to store said available paths grouped by common destination nodes and sorted in each group at least in part by cost, each of said paths having associated with it in said database the wavelengths available on that path.

61. (Previously Presented) The apparatus of claim 60, wherein said database includes a destinations structure to store each of said destinations in a single entry, each of said entries being associated with the sequence of nodes and links of those of the available paths that reach that entries destination.

62. (Previously Presented) The apparatus of claim 60, said access node further comprising:

a disjoint path module, coupled to said database, to select, based at least in part on an input path, a disjoint path from the available paths associated in said database with the same destination node as said input path and select an unallocated wavelengths thereon.

63. (Previously Presented) The apparatus of claim 62, wherein said disjoint path module is at least to determine the intersection of the intermediate nodes of said input path and the intermediate nodes of a candidate path in said database that has the same source and destination nodes as said input path.

64. (Previously Presented) The apparatus of claim 62, said disjoint path module is at least to determine the intersection of the interconnecting links of said input path and the interconnecting links of a candidate path in said database that has the same source and destination nodes as said input path.

65. (Previously Presented) The apparatus of claim 60, said access node further comprising:

a regular path module to select a the first path with an unallocated wavelength from the group of sorted paths in said database associated with an input destination node and select an unallocated wavelength thereon.

66. (Previously Presented) A method performed in an access node of a wave division multiplexing optical network, said method comprising:

responsive to a demand for a path to a given destination node, performing the following,

accessing a database storing available paths with costs from the access node to reachable destination nodes in said optical network, wherein each path is a sequence of nodes and interconnecting links starting at said access node and ending at one of said reachable destination nodes, said available paths being stored grouped by common destination nodes and sorted in each group at least in part by the cost, each of said paths having associated with it in said database the wavelengths available on that path,

selecting the group of sorted paths with the given destination node;

selecting a path with an unallocated wavelength from the selected group of sorted paths having the given destination node; and

selecting a wavelength on the selected path.

67. (Previously Presented) The method of claim 66, wherein said selecting said path further comprises:

selecting the first path in the sorted order with an unallocated wavelength.

68. (Previously Presented) The method of claim 66, wherein said selecting said path further comprises:

accessing from the database the nodes and/or links of the selected path; and

determining that the accessed nodes and/or links are sufficiently disjoint from a set of input nodes and/or links to meet a set of disjointness constraints.

69. (Previously Presented) The method of claim 68, wherein said set of disjointness constraints include one or more of maximally link disjoint, fully link disjoint, maximally node disjoint, and fully node disjoint.

70. (Currently Amended) A method performed in an access node of a wave division multiplexing optical network, said method comprising:

locating a reachable destination node in a structure of a database, wherein said structure stores a non-duplicative set of the plurality of destination nodes in the optical network reachable with available paths from the access node grouped by common destination node, wherein said database associates to each of said plurality of destination nodes in the structure each of the sequences of nodes and interconnecting links of those of the available paths that lead to that destination node sort at least in part by cost, each such available path having associated to it the set of one or more available wavelengths along that path; and

accessing from the database the nodes and/or links of a selected one of the available paths associated with the located one of said plurality of destination nodes; and

selecting from the database an unallocated one of the set of available wavelengths along the selected path.

71. (Previously Presented) The method of claim 70, wherein said method further includes:

determining that the accessed nodes and/or links are sufficiently disjoint from a set of input nodes and/or links to meet a set of disjointness constraints.

72. (Previously Presented) The method of claim 71, wherein the set of disjointness constraints includes one of fully node disjoint, maximally node disjoint, fully link disjoint, and maximally link disjoint.

73. (Previously Presented) The method of claim 70, wherein said available paths are lightpaths.

74. (Previously Presented) The method of claim 70, wherein said available paths are optical circuits.

75. (Previously Presented) The method of claim 70, wherein the database includes for each of the sets of wavelengths a status for each wavelength, wherein said status includes allocated and unallocated states.

76. (Previously Presented) A method comprising:

transmitting to each adjacent node of an access node of a wavelength division multiplexing optical network a connectivity request message to be propagated to determine possible end to end paths having said access node as a source node and meeting a set of zero or more connectivity constraints, wherein an end to end path is a series of two or more of nodes connected by links on which a set of wavelengths is available for establishing a lightpath; and

receiving responsive connectivity messages identifying collected possible end to end paths and a path channel set for each identifying the available wavelengths;

storing in a database the collected end to end paths grouped by common destination nodes;

storing in said database the path channel set for each of the collected end to end paths; and

associating in said database each of the stored path channel sets to the corresponding stored end to end path.

77. (Previously Presented) The method of claim 76, wherein said storing includes in said database the collected end to end paths further comprises:

associating a cost to each of said end to end paths; and

sorting the end to end paths in each group at least in part by said costs.

78. (Previously Presented) The method of claim 77, further comprising:

responsive to a demand for a path to a given destination node, performing the following,

selecting the group of sorted end to end paths with the destination node; and

selecting a path with an unallocated wavelength from the selected group of sorted end to end paths having the given destination node; and

selecting a wavelength on the selected path.

79. (Previously Presented) The method of claim 77, wherein said selecting said path further comprises:

selecting the first path in the sorted order with an unallocated wavelength.

80. (Previously Presented) The method of claim 77, wherein said selecting said path further comprises:

accessing from the database the nodes and/or links of the selected path; and

determining that the accessed nodes and/or links are sufficiently disjoint from a set of input nodes and/or links to meet a set of disjointness constraints.

81. (Previously Presented) The method of claim 80, wherein said set of disjointness constraints include one or more of maximally link disjoint, fully link disjoint, maximally node disjoint, and fully node disjoint.

82. (Previously Presented) The method of claim 77 further comprising:

responsive to a demand for a path to a given destination node, performing the following,

selecting the group of sorted end to end paths with the given destination node;

selecting as an initial path the first path with an unallocated wavelength from the selected group;

selecting as a subsequent path the first path with an unallocated wavelength from the selected group whose nodes and/or links are sufficiently disjoint from the nodes and/or links of the initial path to meet a set of disjointness constraints; and

selecting an unallocated wavelength on said initial path; and selecting an unallocated wavelength on said subsequent path.

83. (Previously Presented) The method of claim 82, wherein said set of disjointness constraints include one or more of maximally link disjoint, fully link disjoint, maximally node disjoint, and fully node disjoint.

84. (Currently Amended) A method performed in an access node of a wave division multiplexing optical network, said method comprising:

selecting, from a database storing available paths with costs from the access node to reachable destinations organized by said reachable destinations and grouped by common destination, a different one of a set of the available

paths associated with the same destination node as a previously selected path, wherein each of said available paths is represented in said database by the series of two or more nodes and the interconnecting links over which that path travels,

wherein each of said available paths in said database has associated to it a path channel set that includes one or more wavelengths common to all of the interconnecting links of that path; and

determining the currently selected path is sufficiently disjoint from the previously selected path to meet a set of disjointness constraints through calculating the intersection set of the nodes and/or links of the currently selected path accessed from said database and the previously selected path; and

selecting from the path channel set in said database associated with said currently selected path an unallocated wavelength.

85. (Previously Presented) The method of claim 84, wherein said available paths are lightpaths.

86. (Previously Presented) The method of claim 84, wherein said available paths are optical circuits.

87. (Previously Presented) The method of claim 84, wherein the database includes for each of the path channel sets a status for each wavelength, said status including allocated and unallocated states.

88. (Previously Presented) The method of claim 84, wherein the set of disjointness constraints includes one of fully node disjoint, maximally node disjoint, fully link disjoint, and maximally link disjoint.